SUSTAINABLE CONSTRUCTION PRACTICES IN AIRPORT PAVEMENT REHABILITATION PROJECTS

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PRESENTED FOR THE
2010 FAA WORLDWIDE AIRPORT TECHNOLOGY TRANSFER CONFERENCE
ATLANTIC CITY, NEW JERSEY, USA

APRIL 2010

ABSTRACT

Project sustainability is many times, if not always, linked to the U.S. Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) certified criteria, better known as green building. But for airport pavement rehabilitation projects, the LEED certification is not available. However, sustainable construction practices have been and are currently implemented in airports around the U.S. Commercial airports such as Boston Logan and Chicago O'Hare have developed successful sustainable construction practices in their rehabilitation projects. Many engineers and contractors are already using sustainable design and construction practices in airport pavement rehabilitation projects, but may not be aware of the benefits and positive environmental impacts of their practices. This paper will highlight sustainable construction practices used at airport pavement rehabilitation projects including asphalt reclamation, concrete pavement recycling, and the traditional LEED registered process for airport buildings. The practices applied by Kimley-Horn and other aviation design professionals have been implemented in general and commercial aviation projects not only for the goal of being sustainable, but as a cost savings technique. For example, the reduction of project truck hauling has resulted in less pollutant emissions and material waste. This paper will also outline the findings of Kimley-Horn's internal research on airport sustainable projects and the available resources for the aviation engineer.

INTRODUCTION

Sustainability has received a lot of attention in recent years with much of the focus on the USGBC LEED rating system. LEED is an internationally recognized green building certification system providing third-party verification that a building or community was designed and built using strategies aimed at improving performance across all the metrics that matter most—energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts [1].

The LEED process was developed by the USGBC to provide building owners and operators a concise framework for identifying and implementing practical and measurable green building design, construction, operations, and maintenance solutions [1]. LEED is a voluntary certification program that can be applied to any building type and any building lifecycle phase and it recognizes performance in several key areas which include Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation in Design, and Regional Priority among others. In 2009, the USGBC launched Version 3 of the LEED for New Construction Rating System which is designed to guide and distinguish high-performance commercial and institutional projects, including office buildings, high-rise residential buildings, government buildings, recreational facilities, manufacturing plants and laboratories. LEED points are awarded on a 100-point scale, and credits are weighted to reflect their potential environmental impacts. Depending on the number of points awarded, the project will be LEED certified, silver, gold, or platinum. While this is effective in providing guidelines and consistency, it is geared towards vertical construction and is not applicable to a large percentage of the projects that airports undertake. Sustainability has a much broader application than just buildings and for airport pavement projects, sustainability extends beyond LEED.

The internationally accepted definition of sustainability, as stated in the 1987 Report of the World Commission on Environment and Development [2], is "meeting the needs of the present without compromising the ability of future generations to meet their own needs." In other words, minimizing our impact on the earth—a concept that has been in practice long before the term "sustainable" was coined. In some cases, it was with a deliberate attempt to be environmentally responsible while in others, it simply made good economic or engineering sense. As we continue to focus on sustainability, it is important to look back at some of these practices that truly impact "the ability of future generations to meet their own needs", both positively and negatively. We need to recognize those elements of sustainable design that may not have been categorized as such, and look for opportunities to take advantage of them in the future.

AIRPORT SUSTAINABILITY

Airport Sustainability has been referred to as a holistic approach to managing an airport to ensure the integrity of the social, environmental, and economic elements, or the defined "*triple bottom line*" of sustainability [3]. Airport operators and stakeholders are already implementing sustainable practices that strive to find a balance between economic viability, operational efficiency, natural resource conservation and social responsibility of the airport. Sustainability is often part of every airport rehabilitation project; however the current "green building" trends have made these practices a mandate by many government agencies. Engineers and planners are becoming well versed in airport sustainability practices and many times include these practices because they make good engineering sense and result in better construction projects. Sustainability is frequently paired with the LEED rating system. For airport pavement rehabilitation projects, the LEED rating system is not available unless the rehabilitation includes terminal building structures. However, the LEED rating system does include sustainable practices that can be applied to pavement rehabilitation projects such as recycling materials, reducing heat island effects, permeable pavement design, and innovation uses of residue and waste materials such as fly ash. The LEED reference guide manual [1] can be a valuable resource for airport sustainability design and construction. But LEED is not, nor should be, the sole measure of sustainability. It is possible for a project to be LEED certified without meeting other criteria for environmental efficiency such as Energy Star designations. Several major airports have moved forward with their own guidelines that are often adaptable in whole or in part to other airports. These include Los Angeles World Airports (LAWA) "Sustainable Airport Planning, Design and Construction Guidelines" and Chicago's O'Hare Modernization Program Sustainable Design Manual, but other airports have issued their own standards as well. Current research efforts by the Transportation Research Board (TRB), the Sustainable Aviation Guidance Alliance (SAGA), and ACI among others will develop additional standards, creating some overlap between them all. But there are many good resources available now for airport engineers and stakeholders to develop and implement significant sustainable elements into airport rehabilitation projects. The goal should be to pick the best options for each situation and design in an environmentally responsible manner while still following good engineering principals.

AIRPORT SUSTAINABLE PRACTICES

Most airport pavement rehabilitation projects can include sustainable elements to reduce the environmental impacts and often, save costs as sustainability does not necessarily increase the cost of an airport rehabilitation project. A sustainable project should be able to provide economic benefits and returns to the community, the airport, and stakeholders. Sustainability practices are constantly being developed and many of these practices have been captured through reference guides such as the Sustainable Aviation Resources Guide published by SAGA [4]. Overall, SAGA recommends that airport management should determine what sustainability means to that specific organization or the individual airport facility because not all airports are the same and the efficiency of sustainability practices will vary depending on the unique nature of the airport and the surrounding community. The airport sustainability practices are easily developed on a project-by-project basis as collaboration between the airport and the engineers to integrate sustainable elements into rehabilitation projects. Many airports have adapted the LEED program and created airport-specific sustainability guidelines and metrics for their particular programs [4]. These sustainable practices can be applied to airside and landside projects, some of these practices include the following:

- Reuse of concrete and asphalt as base materials (i.e. rubblization, asphalt millings, etc.)
- Processing of on-site materials for aggregate base courses
- Salvage base material
- Warm Mix Asphalt
- Roof overhangs in parking facilities
- Parking revenue control can reduce dwell times of vehicles exiting parking (lower emissions)
- Collection of runoff and grey water for irrigation of landscape areas
- Reuse of light fixtures and signs
- Pervious pavement system in parking lots and driveways
- LED lighting fixtures in parking facilities
- Energy efficient LED airfield lighting;
- On site asphalt plant reducing truck hauling resulting in fuel savings and pollution reduction;
- On site material recycling reduces haul and energy used in production of new materials. Material recycle could include asphalt reuse, base course reuse for stabilization which results in pollution reduction and control practices during construction;
- Water use; building fixtures but also landscape systems, permeable pavement, redirecting drainage to swales for percolation back into soil;
- Geothermally heated pavement, with solar augmentation, to eliminate use of de-icing chemicals (Potassium Acetate) and reduce plowing.

The airport industry has many current leaders in sustainability. These are airports that have been implementing successful sustainability elements into their airport rehabilitation projects. Examples of sustainable practices using innovative asphalt materials include the Boston Logan International Airport Runway 4R/22L rehabilitation which consisted of the placement of 25,952 tons of warm mix asphalt making it the first airport in the nation to use the environmentally friendly asphalt on a runway repaving project [5]. The Chicago O'Hare International Airport has also documented their sustainable practices through their O'Hare Modernization Program (OMP); their airside sustainability practices include the rehabilitation of Runway 9L-27R which used approximately 20 to 50% regional manufactured and extracted materials, respectively, 5 to 10% recycled content materials including concrete recycling and balanced earthwork to minimize off site hauling [6].

There are many sustainable practices that can be implemented at airport rehabilitation projects and the designers must inform the airport client of the available resources and practices being implemented in airports across the country. The SAGA Sustainable Aviation Resources Guide [4] presents outlined examples demonstrating how airports can approach, execute, and manage airport sustainable projects and provides a comprehensive database of available resources for developing and implementing sustainable practices. The SAGA database is the first compilation of sustainable practices from different domestic and international airports. The Airport Cooperative Research Program (ACRP) also presented its findings of a synthesis which included a literature review and a web-based survey of U.S. and non-U.S. airports' sustainable practices [7]. Among its findings the synthesis identified drivers, priorities, and barriers for implementing airport sustainable practices. The extensive list of existing and future drivers of sustainability, priorities and barriers all had a common factor - economic.

AIRPORT SUSTAINABILITY PROJECTS

Kimley-Horn and Associates, Inc. created a Sustainability Group that has been focusing on the compilation of available airport sustainability practices and resources within the firm as well as from outside organizations such as SAGA, TRB, and the Airport Cooperative Research Program (ACRP) among others. In subsequent sections, several of these airport sustainability practices will be highlighted to illustrate how sustainability has been implemented in different types of airport rehabilitation projects.

One of the most common sustainable elements of any pavement rehabilitation project is the reuse of existing materials to the greatest extent possible. In roadway projects, most Department of Transportation (DOT) offices allow the use of recycled asphalt in new pavement surface courses. In Florida, this recycled content can be as high as 50% of the total weight and the use of recycled asphalt pavement (RAP) is encouraged [8]. In contrast, the Federal Aviation Administration specification P-401 Plant Mix Bituminous Pavements allows for use of a maximum of 30% RAP and limits it to lower layers and paved shoulders [9]. While the use of RAP is allowed in the lower pavement layers, it is often not used in airside rehabilitation projects. This may be due in part to the difficulties in achieving compaction and the need to complete additional test strips, as well as the need to submit two bituminous pavement design mixes and change the plant set up in mid production.

Moreover, there are other ways to recycle materials in airport pavement rehabilitation projects. In 1985, KHA led the design for the airside and landside elements of the Palm Beach International Airport (PBI) new terminal project. The airport had an immediate need to alleviate parking shortages in both their long-term and short-term parking lots to bridge the time until the new terminal and parking facilities where completed. Additionally, the site of the future terminal and parking lot needed to be cleared of existing buildings and sidewalks. The Interim Long Term and Short Term Parking Lot improvement project was designed to use recycled concrete as the base course for the asphalt pavement parking lot. All the concrete from the demolition of buildings, sidewalks and curbs was recycled on-site using a portable crushing plant that pulverized the concrete and removed the reinforcing steel. When using the material, it was found that it provided a high quality base course at substantially reduced costs. All density requirements were easily met and the only difficulty that could have been encountered was if the material was not worked to final grade quickly enough. In that case, the rehydrated cement fines would harden again making the surface very difficult to grade. The environmental savings attributable to the reuse of this existing material included not only the recycling of the material which preserved landfill space and virgin resources, but reduced hydrocarbon emissions due to mining and trucking new materials and hauling waste materials to the landfill. Photos 1 and 2 show the PBI terminal construction and materials recycling process.

Photo 1. PBI New Terminal Construction Project
Concrete Recycling (1985)

Photo 2. PBI New Terminal Construction Project
Pavement Recycling (1985)

Fort Lauderdale Executive Airport (FXE) is a large general aviation airport in Broward County, Florida. The airport has over 700 based aircraft and it is one of the top 10 general aviation (GA) airports in terms of annual operations. In January, 2004, plans were completed for the mill and overlay of the primary Runway 8-26. The pavement section called for milling the existing runway a minimum of 2 inches, then overlaying with a variable depth leveling course and a final 2-inch P-401 Bituminous surface course. Due to the variations in the depth of the leveling course, it was decided not to allow RAP in the leveling course, and the FAA specification prohibited the use of RAP in the final lift. However, the airport had other needs that could be met by using the milled asphalt from the runway. Specifically, there was no interior perimeter road system around the airport for use by maintenance, security and operations personnel. This caused unnecessary delays as vehicles waited for clearance to cross the main runway. The plans were prepared to include construction of an interior perimeter road that went around both ends of the runway, outside the runway safety areas. The project specifications called for clearing and compaction of the existing subgrade layer and placement of 8 inches of milled asphalt to create the roadbed. No special preparation was undertaken to the milled material and it was cold placed in the same condition it came out of the milling machines, then graded and compacted. The typical section was design 20 feet wide and crowned with a 2 percent cross slope. As the area was relatively flat, no longitudinal grades were set and the road was allowed to follow existing surface contours. The subsurface soils were primarily sandy and runoff percolated into the ground very quickly. Consequently no provisions were made for drainage improvements. The contractor was compensated on a per square yard basis. While the end result did not yield the smoothness of a conventionally constructed road, it achieved the goal of providing a serviceable road for the intended users at a very low cost. From a sustainability perspective, the reuse of this material resulted in reduced emissions both during construction due to the onsite reuse, and the future reduction of wait and engine idle times for vehicles waiting to cross the main runway. Additionally, had the airport built a conventional road for this purpose, the use of new materials would have had environmental impacts as well.

FXE has continued to use millings in other areas of the airport. The airport has a mid-field run-up area used for maintenance testing of jet aircraft that had a berm around it, but was continually experiencing erosion due to jet blast. This resulted in sand being blown across the adjacent Taxiway Golf to the degree that the Air Traffic Control Tower (ATCT) would not use Taxiway Golf when an aircraft was in the run-up area. A conventional blast fence was not an option due to line of sight issues from the ATCT. The Runway 13-31 Pavement Rehabilitation project was designed and built in 2006. Similar to the Runway 8-26 project, it called for milling 2 inches of the existing surface course and overlaying with a variable thickness leveling course and a 2-inch P-401 bituminous surface course. The contractor was instructed to spread asphalt millings on and around the berm for the run-up area. The thickness was not specified as it was intended to allow the contractor to dispose of material without the cost of hauling it offsite.

In 2007, FXE undertook the relocation of Taxiway Alpha. This taxiway was parallel to runway 8-26 and extended partially in the runway safety area, resulting in use restrictions of the taxiway. The FAA required the airport to relocate it approximately 90 feet south of its current location to alleviate this condition. The existing limerock base course was recycled into the stabilized subgrade course of the new taxiway. The project was phased to close sections of the taxiway and allow demolition of the old and subsequent construction of the new section before the area was reopened. The limerock removed from the old Taxiway Alpha was stockpiled in the work area for each phase, and then reused in the stabilized base course of the new Taxiway Alpha.

FXE actively looks for opportunities to be environmentally responsible. When the decision was made to construct a new Aviation Equipment and Service Facility, the airport decided to apply for LEED certification for the 7,421 square foot building on a 2.1 acre site. The project was reviewed by the USGBC and Table 1 summarizes the earned LEED design credits (or points).

Table 1.
FXE Aviation Equipment and Service Facility LEED Credit Summary

Credit Intent	Design Points
Sustainable Sites	8
Water Efficiency	5
Energy and Atmosphere	5
Indoor Environmental Quality	8
Innovation and Design Process	1
Total Design Points Earned	27*

*Official LEED v2 Point Rating:
Certified: 26-32 Silver: 33-38 Gold: 39-51 Platinum: 52+

The civil engineering design elements included the following sustainable elements:

- Sustainable Sites Credits
  - Erosion and Sedimentation Control (ESC) Plan
    - The ESC Plan conformed to the 2003 EPA Construction General Permit, which outlines the provisions necessary to comply with Phase I and Phase II of the National Pollutant Discharge Elimination System (NPDES) program.
    - This is a pre-requisite for LEED certification. No points are awarded for pre-requisites.
  - Site Selection (1 point)
    - The project was not developed on the following sites:
      - Prime farmland
      - Land which is specifically identified as habitat for any threatened or endangered species
      - Within 100 feet on any wetland, or areas of special concern
      - Previously undeveloped land that is within 50 feet of a water body
      - Land which prior to acquisition for the project was public parkland
  - Alternative Transportation (4 points)
    - Public Transportation Access
      - Bus Service – Project is located within ¼ mile of one or more stops for two or more public or campus bus lines usable by building occupants.
    - Bicycle Storage and Changing Rooms
      - The project is non-residential and it provides bicycle storage facilities to serve 71.42% of full time equivalent (FTE) and

transient building occupants, measured at peak occupancy, and shower facilities for 14.28% of the FTE. Plans were provided showing the location of the shower/changing facilities and the bike storage facilities located within 200 yards of an entrance to the facility.

- Low Emitting and Fuel Efficient Vehicles
  - 2 preferred parking spaces were provided for low-emitting and fuel efficient vehicles which represented 15.3% of the total onsite parking.
- Parking Capacity (13 total spaces)
  - On-site provided parking did not exceed the minimum local zoning requirements and the car/van pool parking was provided for a minimum of 7.69% of the total provided parking spaces.

- Stormwater Design (2 points)
  - Quantity Control
    - Project met the requirements for the existing imperviousness of less than or equal to 50% by implementing a stormwater management plan that retains runoff on-site and allows it to gradually infiltrate into the soil.
  - Quality Control
    - Project will implement a stormwater management plan that reduces impervious cover, promotes infiltration, and captures and treats the stormwater runoff from 100% of the average annual rainfall using acceptable Best Management Practices (BMPs). The project's BMPs are capable of removing 80% of the total suspended solids (TSS) from the average annual post-development runoff.
- Heat Island Effect: Roof (1 point)
  - Roofing materials used on the project have a Solar Reflectance Index (SRI) value of 106 for the low-sloped roof, covering 99.73% of the roof surface.
    - SRI value of at least 29 must be provided. For the Heat Island Effect: Non Roof credit, concrete pavements designs can be provided to achieve a pavement with an SRI of 29.

With design complete, the project team achieved enough credits to be certified and anticipates obtaining 15 additional construction points to achieve a final LEED Gold rating. Photo 3 shows a rendering of the proposed facility which is currently under construction.

Photo 3. FXE Aviation Equipment & Service Facility Rendering

The City of Tallahassee, which owns the Tallahassee Regional Airport (TLH) has a policy requiring all city projects, must evaluate the potential use of sustainable practices. While the North and Old Terminal Apron project preceded that policy, the Airport benefitted from sustainable design practices for non-vertical construction because the solution made good engineering sense. Designed in 2008 and currently under construction, the North and Old Terminal Apron rehabilitation project reconstructs 14.75 acres of existing apron with 5 different existing pavement sections. The existing asphalt sections are being milled and overlaid. The Old Terminal portion of the apron consists of approximately 3 inches of asphalt over 16 inches of old concrete pavement. That 6.4-acre area called for the removal of the asphalt and subsequent rubblization of the concrete pavement using a resonant breaker machine. The result is a base course meeting the FAA P-215 Rubblized Portland Cement Concrete Base Course specification without the environmental impacts of removing the 16 inches of concrete (approximately 13,750 cubic yards) and replacing it with virgin material. Photos 4 and 5 show the TLH North Apron rubblization process.

Photo 4. TLH North and Old Terminal Apron Rehabilitation
Rubblization of Concrete Apron (2010)

Photo 5. TLH North and Old Terminal Apron Rehabilitation
Rubblization of Concrete Apron – Test Pit (2010)

As part of the TLH North and Old Terminal Apron project, the plans and specifications also called for a temporary access road alongside the pavement to avoid heavy construction and airport operations traffic on the sections under construction and to avoid traffic delays for essential airport operations. The first section of milling provided the material for construction of this bypass service road that allowed airport vehicles, including refueling trucks, to operate without passing through subsequent construction areas. This temporary access road was similar to the FXE access road and was built out of asphalt millings (photo 6).

Photo 6. TLH North and Old Terminal Apron Rehabilitation
Temporary Access Road – Asphalt Millings (2009)

An additional sustainable practice used at the TLH North and Old Terminal Apron project was the recycling of the concrete slab of the old terminal foundation. The airport requested that the contractor reuse the broken concrete pieces in an isolated eroded drainage area of the airport as rip rap (photo 7). This practice further decreased the truck hauling emissions and the amount of construction waste produced by the project.

Photo 7. TLH North and Old Terminal Apron Rehabilitation
Concrete Slab Foundation Recycling (2009)

The South Apron Rehabilitation project at TLH, which is currently waiting for funding, had conditions that required an entirely different approach, albeit one which can be considered sustainable. The project includes rehabilitation of 18.25 acres of the general aviation apron. During the subsurface investigation, it was found that the west end of the apron had pavement sections with more than adequate base and surface course to areas that were deficient. There was no clear delineation of the areas that could be determined and the conditions found in the field did not match the record drawings for construction in the area. The conventional solution was to remove and reconstruct approximately 7.3 acres of apron. Instead, the design included in-place reclamation of the existing base and asphalt surface courses as new base material. The reclamation process specifies for the contractor to mill out the useful asphalt and limerock material until enough has been stockpiled to re-process (recycle) and pave at the new required base course depth of 6 inches. They will remove the material to maximize the amount of asphaltic material, cutting deeper in sections with more asphalt, and staying out of underlying clays in areas where the cross sections have less overlay and limerock. Once the contractor has enough recyclable material, they will strip the rest of the base to get the elevations and cross slopes prepared for the new layers. This excess material can either be taken off site or stockpiled for the airport to use on future projects. Once the subbase is set to grade and compacted, the contractor will begin processing the RAP material by screening and mixing it through a central plant (pug mill). Emulsion will be added per a laboratory mix design generated using samples taken from the apron. This material will be hauled to a paver, placed, and compacted similar to a standard asphalt base course. After the curing period two lifts of hot mix asphalt will be placed to a thickness of 4 inches. It is anticipated that 60% of the material removed will be recycled on site. Additionally, construction time for this process is anticipated to be faster than conventional construction of a new limerock base course and P-401 bituminous surface course.

The TLH airport will continue to use sustainable airport practices in future taxiway rehabilitation projects. The Taxiway Zulu rehabilitation project is also waiting funding and it includes the reuse of asphalt millings for shoulder stabilization and erosion control due to helicopter rotor wash.

McClellan-Palomar Airport, in San Diego County, California, will also be using in-place recycling to reconstruct Runway 6-24. This project includes the recycling of the existing asphalt surface course as new base course. The project will be going into construction soon.

Telluride Regional Airport in Colorado used asphalt millings as base course under paved shoulders for its Runway 9-27 rehabilitation project. In addition, the contractor for Northwest Arkansas Regional Airport Taxiway Alpha project is recycling about 2/3 of the asphalt millings from the old service road into a new road. Furthermore, concrete from duct banks, end walls and pipe is being crushed and reused for erosion control.

CONCLUSION

All of the airport sustainable practices previously mentioned contribute to the triple bottom line of sustainability—social, environmental, and economic benefits. There are many additional sustainable practices that can be implemented at airport rehabilitation projects and the designers must inform the airport client of the available resources and practices being implemented in airports across the country and around the world. One of the most important factors in a sustainable airport project is the collaboration between the airport, engineering and contractor team. The project contractors can also contribute to implementing more sustainable practices based on previous project experience. Ultimately, sustainability must become a standard component of all airport design and construction projects. Within the next few years it can be expected that sustainability will be common practice for most airports regardless of location, size and community services (i.e. general vs. commercial aviation). Sustainable design is not just a current trend, but the future of airport design and construction. We all share the responsibility to embrace these sustainable practices and find the balance between the social, environmental, and economic elements for all airport projects.

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